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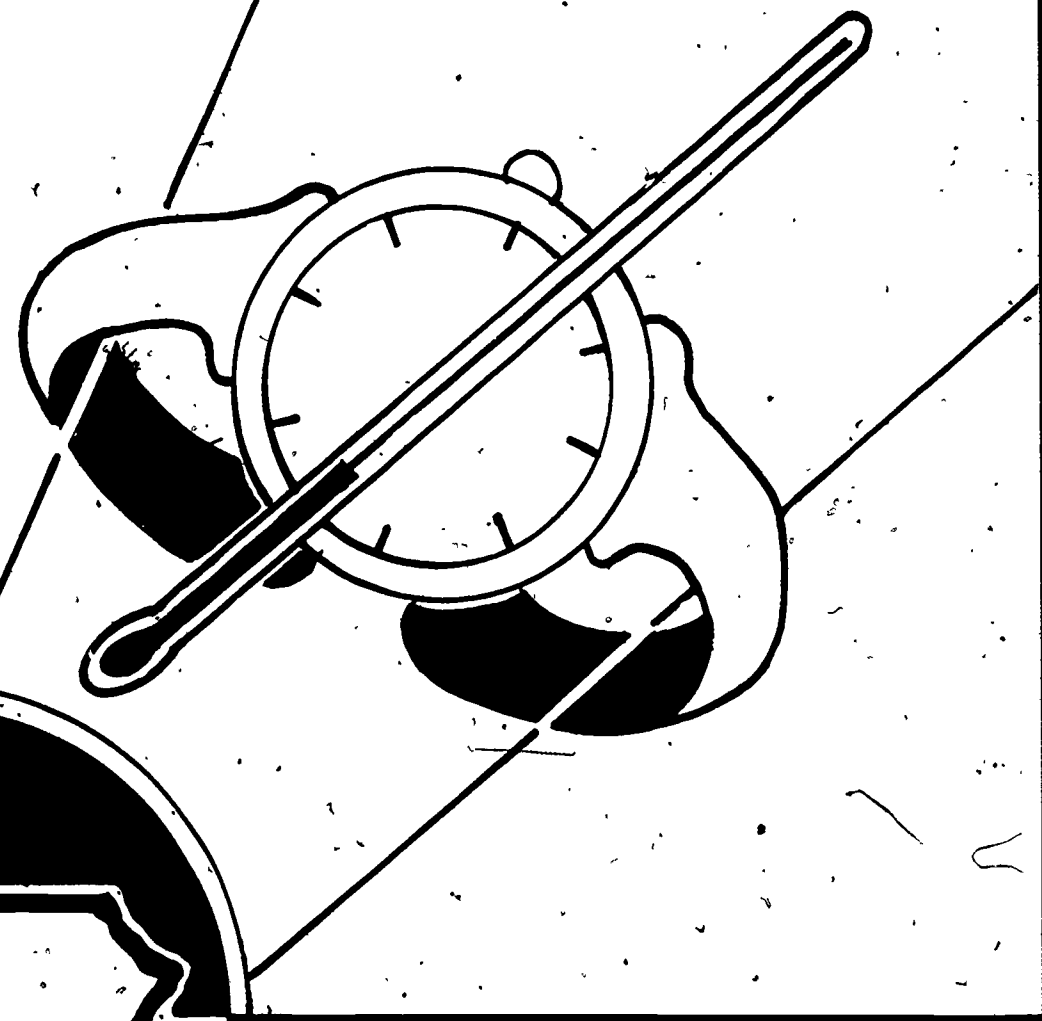
ABSTRACT

This module on the nervous system is one of 17 modules designed for individualized instruction in health occupations education programs at both the secondary and postsecondary levels. It is part of an eight-unit miniseries on anatomy and physiology within the series of 17 modules. Following a preface which explains to the student how to use the module, the unit consists of a pretest with answers, four sections (information sheets) with their objectives (e.g., describe the general organization of the nervous system), optional activities (e.g., investigate spinal cord injuries and the different results of injuries at different levels of the cord), and posttests, and a glossary of terms. Topics covered in the unit are introduction to the nervous system, nerve impulse conduction, the central nervous system, and the peripheral nervous system. An accompanying instructor's guide contains suggestions for using the module and answers to the posttest. (KC)

HEALTH OCCUPATIONS EDUCATION MODULE



THE NERVOUS SYSTEM

Instructional Materials in Anatomy and Physiology
for Pennsylvania Health Occupations Programs

THE NERVOUS SYSTEM

Prepared for:

Research Coordinating Unit for Vocational Education
Pennsylvania Department of Education
Box 911
Harrisburg, Pennsylvania 17126

Prepared by:

National Evaluation Systems, Inc.
30 Gatehouse Road
Amherst, Massachusetts 01002

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PREFACE

An understanding of basic human anatomy and physiology is essential to any person preparing to enter a health occupation. This instructional unit is designed to introduce you to the structures and functions of the human nervous system--and the interrelationships of the two--and to familiarize you with some of the terms and concepts necessary for an understanding of the nervous system.

This unit consists of a pretest, four modules with their optional activities, a glossary of terms, and a post-test.

Begin this modular unit by taking the brief pretest at the front of the booklet. Write your answers on a sheet of paper and pass it in to your instructor.

Next, read through each of the modules (Introduction to the Nervous System, Nerve Impulse Conduction, The Central Nervous System, and The Peripheral Nervous System) and investigate any of the optional activities that may be helpful or interesting to you. The optional activities will help you learn more about some of the materials presented.

At the end of this unit is a glossary which provides you with brief definitions of many of the terms used in the modules.

Upon completion of this unit, you should be able to demonstrate an understanding of the material presented by your performance on the post-test. When you have finished this unit, and feel that you understand the information presented, take the post-test that follows. Write down your answers on a sheet of paper and pass it in to your instructor, who will give you your grade.

The Nervous System
PRETEST

1. Name the two divisions of the autonomic nervous system.

_____

_____

2. A nerve cell is known as a:

_____

3. The nervous system relays coded communications from one area of the body to another through the transmission of:

A. chemicals.
B. impulses.
C. senses.
D. stimuli.

4. The junction between two nerve cells is called a:

A. threshold.
B. stimulus.
C. reflex.
D. synapse.

5. The long, thin part of a nerve cell that conducts impulses away from the cell body is called the:

_____

6. The major controlling organ of the nervous system is the:

A. spinal cord.
B. heart.
C. brain.
D. stomach.

7. Name the two organs of the central nervous system.

_____
_____

8. The three membranes that surround the organs of the central nervous system are collectively called the:

_____
_____
_____

9. The portion of the brain that is responsible for smooth and balanced executions of movements is the:

A. cerebellum.
B. pons.
C. hypothalamus.
D. medulla.

10. Which part of the brain contains cardiac, respiratory, and vasomotor centers?

A. interbrain
B. midbrain
C. pons
D. medulla

11. Name the three major divisions of the brain.

_____

_____

_____

12. There are how many pairs of spinal nerves?

A. 8.
B. 12
C. 20
D. 31

13. The 12 pairs of nerves arising from the brain that supply fibers to the head, neck, and chest regions are the:

_____

14. Name the division of the autonomic nervous system that prepares the body for dangerous or stressful situations.

_____

15. In several body regions, groups of spinal nerves form complex networks called:

A. effectors.
B. plexuses.
C. receptors.
D. reflexes.

16. List the three autonomic nervous system effectors.

_____

_____

_____

17. Which of the following is a major function of the spinal cord?

A. controlling reflexes
B. producing cerebrospinal fluid
C. initiating breathing
D. regulating internal temperature

18. Which structures of the brain are filled with cerebrospinal fluid?

A. nerves
B. ventricles
C. hemispheres
D. lobes

INTRODUCTION TO THE NERVOUS SYSTEM

Objectives

Upon completion of this module, you should be able to:

1. Describe the general organization of the nervous system.
2. Identify the basic functions of the nervous system.

Although both humans and trees are living organisms sharing the same environment and having many of the same basic requirements for survival, there are countless differences between you and the trees outside your window. Some of the most significant differences are due to the fact that you have a nervous system and the tree does not. For that reason, you can perceive and react immediately to changes in your surroundings, move about at will, and perform many other activities you probably never stop to think about. Just what the nervous system does, and how it does it, is the subject of this modular unit.

The nervous system is based on a single basic unit, the nerve cell. Yet in terms of both organization and operation, the nervous system can be divided into two subsystems, the central nervous system and the peripheral nervous system. Though largely interlinked, these two divisions are quite distinct.

The central nervous system is the core of the nervous system, central in both its physical and functional position. There are only two organs in this subdivision: the brain, and its extension, the spinal cord. The brain is the great controlling unit of the nervous system, the organ to which all parts of the system lead and upon which all parts of the system depend. The spinal cord is in structure and function rather like a thick cable of communication lines. It serves as the connection between the brain and the rest of the body. However, the cord is more than merely a channel for brain-to-body messages. It too exercises a measure of control over certain body activities, especially those called reflex actions.

The peripheral nervous system extends from its roots in the central nervous system to the periphery of the body. This subsystem includes 12 pairs of cranial nerves which originate in the brain, and 31 pairs of spinal nerves which arise in the spinal cord and reach, in some cases, to the outermost surfaces of the body, to the sensory organs, and to the body's muscles.

The autonomic nervous system is classified as part of the peripheral nervous system. It is linked to the central nervous system by some of the cranial and spinal nerves. This system is called autonomic, or independent, because it usually operates

beyond the level of conscious control. It is made up of two counterbalancing divisions, the sympathetic and the parasympathetic systems. These two subdivisions have generally opposing effects on body organs, and between them check and balance each other in the regulation of body processes.

The nervous system functions as a whole to gather, process, and act upon information available to the body from the environment, both the external environment of the world around us and the internal environment of the body itself. A vital part of this process is the activity of impulse transmission within the nervous system. Impulse transmission is the relaying of coded communications from one area of the body to another. The transmission is carried out by the basic unit of the nervous system, the nerve cells. The communications which are passed along can be information gathered by the special senses (sight, hearing, taste, touch, or smell), or they can be information about the internal state of the body. The central nervous system instructs the body how to deal with what's going on internally and externally through messages sent to the muscles, glands, and organs of the body. Through these messages the nervous system performs another of its functions: coordinating the movement of the body's various muscles.

As will be seen in the following modules, the structure of the nervous system is ideal for its task: the task of body-wide information gathering and communication about the inner and outer environments of the body, and linking and controlling thousands of activities, systems, and functions of the human body.

NERVE IMPULSE CONDUCTION

Objectives

Upon completion of this module, you should be able to:

1. Identify the types of neurons.
2. Describe the structure of neurons.
3. Identify and describe the structures and processes involved in nervous impulse conduction.
4. Describe the mechanism of a reflex arc.

Communication is the basic function of the nervous system. The nerve cell or neuron is the basic unit of the nervous system; it is structured specifically to transmit the system's communications throughout the body as simply and efficiently as possible. The neuron's tasks consist of receiving, conducting, and referring the incoming communications--or impulses--from one part of the system to the next.

The design of the neuron reflects its function (see Figure 1). The neuron, like any other cell, has the cell body as its central or main part. This is the bulkiest area of the cell and contains the nucleus and other necessary cell structures. The neuron differs from other cells in that the cell body continues into a long, thin, stem-like projection called the axon. The axon can be tremendously long. For instance, the axon of a neuron in the foot can extend the entire length of the leg up to the lower part of the spinal cord. This part of the nerve cell conducts nervous impulses away from the cell body, rather like a wire that conducts electrical current away from a battery. Axons, like wire, require some kind of insulation in order to conduct the impulses efficiently. In the nervous system, this insulation is provided by a white, fatty substance wrapped around the axon called myelin. Myelin makes the axons appear white, especially if there are many axons bundled together. (Axons bundle together like cables to form nerve tracts.).

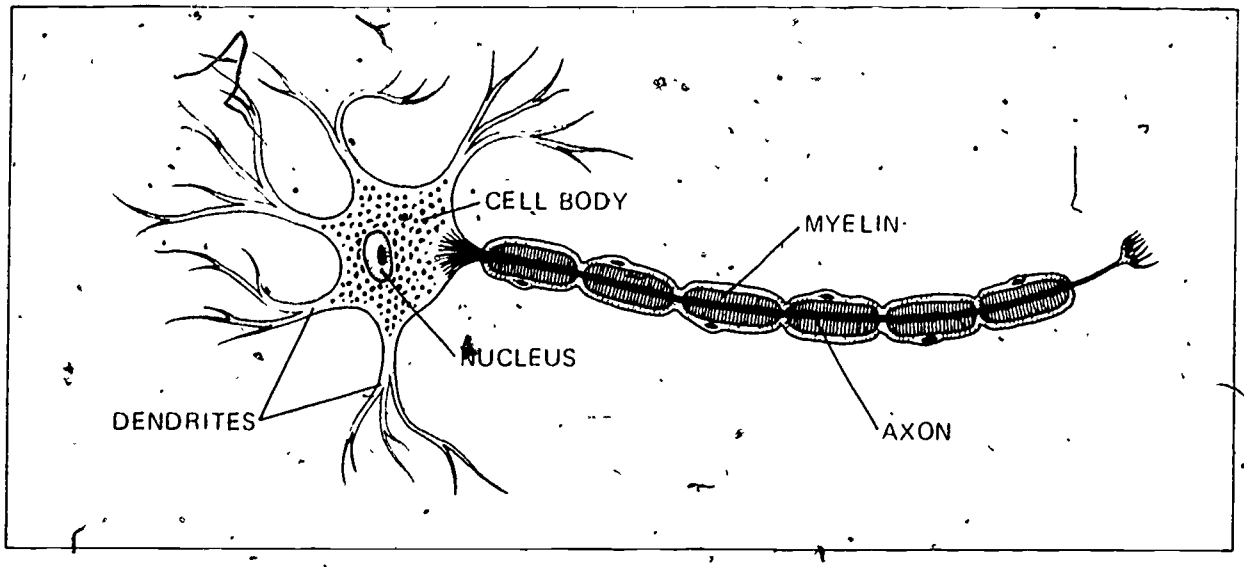


Figure 1. The Neuron

Axons are unique to nerve cells; so are the structures called dendrites. Dendrites are often compared to microscopic tree branches growing out from the neuron cell body. They are fine, multiple-branching fingers that receive incoming impulses from various sources; from axon ends of other nerve cells, or directly from the environment. The dendrites then pass the impulses to the cell body. The only path an impulse can follow through a neuron is from dendrite, to cell body, to axon.

The communications passing through the nervous system travel in two directions, from the peripheral to the central nervous system and vice-versa. Sensory neurons are those nerve cells that bring messages to the central nervous system. The sensory neurons originate in areas that experience the environment: the skin, eyes, nose, tongue, and so on. Their function is to receive information about the environment and the state of the body and relay it to the spinal cord and brain. Motor neurons relay impulses in the opposite direction, from cord and brain back to the body parts. The motor neurons originate within the central nervous system from which they receive the impulses they conduct. Most of the axons of motor neurons end in muscles. Impulses traveling along motor neurons are relayed to muscle tissue. Muscles contract in response to the impulses to produce some kind of movement. Thus, motor neurons function to conduct impulses from the central nervous system to the tissues, which can then act in response.

Association neurons (or interneurons) lie between the sensory and motor nerve cells. The association neurons are found only in the brain and spinal cord, where they transmit impulses between other neurons. In a typical nerve pathway, an impulse travels from a sensory neuron through one or more association neurons, and from there to a motor neuron. Association neurons channel incoming (sensory) information, either routing it to higher levels in the central nervous system or managing it themselves. Much of the brain is made up of association neurons.

In order for the nervous system to be able to relay information from one part of the body to another, each neuron must be capable of receiving, conducting, and transmitting impulses. Certain properties of neurons ensure that these processes can occur; these properties include excitability, conductivity, and adherence to the all-or-none law. A neuron is extremely sensitive to appropriate incoming signals (or stimuli), whether the stimulus comes from the environment or from another neuron. The neuron will react to the stimulus by generating an impulse. This is the property of excitability. Once the stimulus has excited the neuron and the cell has produced an impulse, the impulse must then be transmitted along the neuron to reach its next destination within the nervous system. This transmitting activity depends on the property of conductivity. An impulse generated within an excited neuron will be conducted through the entire nerve cell. Some stimuli are too weak and must be ignored by the nervous system. Only stimuli of a certain strength will cause a neuron to generate an impulse, and the impulse generated must be of a certain strength to guarantee its further conduction. Therefore each impulse generated or conducted is the strongest impulse the cell can produce; it will then travel the entire length of the neuron without dying out. Each neuron is capable of generating only one strength or type of signal. This signal, or impulse, will be produced only if the stimulus that generates it is strong enough. This principle is rather like the mechanism of a line of

falling dominoes: either the dominoes fall, or they don't. If they are knocked hard enough to fall, then they fall all the way over to the next domino. If not, then they remain standing and nothing happens. In nervous conduction, this principle is called the all-or-none law.

The transmission of an impulse along an individual neuron is an electrical occurrence; however, impulse transmission across the junction between neurons is a chemical occurrence. This is due to the structure of these connections. Neurons do not come into direct contact with each other. There is a very small space between the axon end of one neuron and the dendrites of the next neuron. This gap is called the synapse. Electrical impulses cannot pass across the synapse; instead, impulses are carried across the gap by chemical transmitters. An impulse arriving at the axon end of an excited neuron will cause the release of chemical transmitter substances from the axon. These chemicals flow across the synapse to the dendrites of the next neuron where they generate an impulse in the next neuron. It may seem odd that a connection between two conducting cells should consist of a gap, but the structure of the synapse aids in the efficient functioning of the nervous system. Because dendrites are sensitive to the transmitter chemicals while axons are not, an impulse can travel across a synapse in only one direction. The property of fatigue is another advantage peculiar to the synapse. The chemical transmitters are constantly manufactured in the axon ends; even so, too much impulse conduction will eventually use up the supplies of transmitter substances. When there is no more chemical transmitter left, impulses can no longer be conducted across the synapse. Fatigue fulfills a protective function by preventing the nervous system from becoming overstimulated and overloaded. Once the supplies of chemical transmitters are brought again to normal levels, impulse conduction across the synapse can resume as normal.

Coordination is another of the functions of the nervous system (communication and coordination are very closely related). The nervous system is organized in such a way that it can coordinate everything occurring between input to the body, and the body's reaction. Receptors monitor the environment. A receptor is a sensory neuron, usually a part of a sensory organ (for instance, the eye or the skin). The receptors transmit impulses in response to specific stimuli: the eyes respond to light, the skin to touch, and so on. These impulses pass to the conductors or the interneurons which conduct them to the appropriate level of the central nervous system. Conductors then relay the resulting impulses from the central nervous system to the effectors. Effectors are the systems or structures that are capable of receiving and acting upon instructions from the central nervous system. Besides the skeletal or voluntary muscles, effectors include the smooth or visceral muscles and the glands. Any of these structures will, when stimulated by the conductors, produce an action suitable to the central nervous system's decision on how to respond to incoming stimuli.

The reflex arc is a simple example of such a stimulus-reaction pattern. A reflex arc is capable of detecting change, and causing a response to that change, without conscious control. At its lowest level the reflex arc is a three-neuron circuit between a receptor, an interneuron, and an effector. (See Figure 2). The circuit synapses somewhere within the central nervous system (for example, the spinal cord). The receptor generates an impulse in response to a stimulus from the

environment. This impulse passes to an afferent (sensory) neuron, which conducts it to the central nervous system. Here it synapses with an interneuron which then synapses with an efferent (motor) neuron. The efferent neuron conducts an impulse back to the appropriate effector; the effector then produces a reflex action.

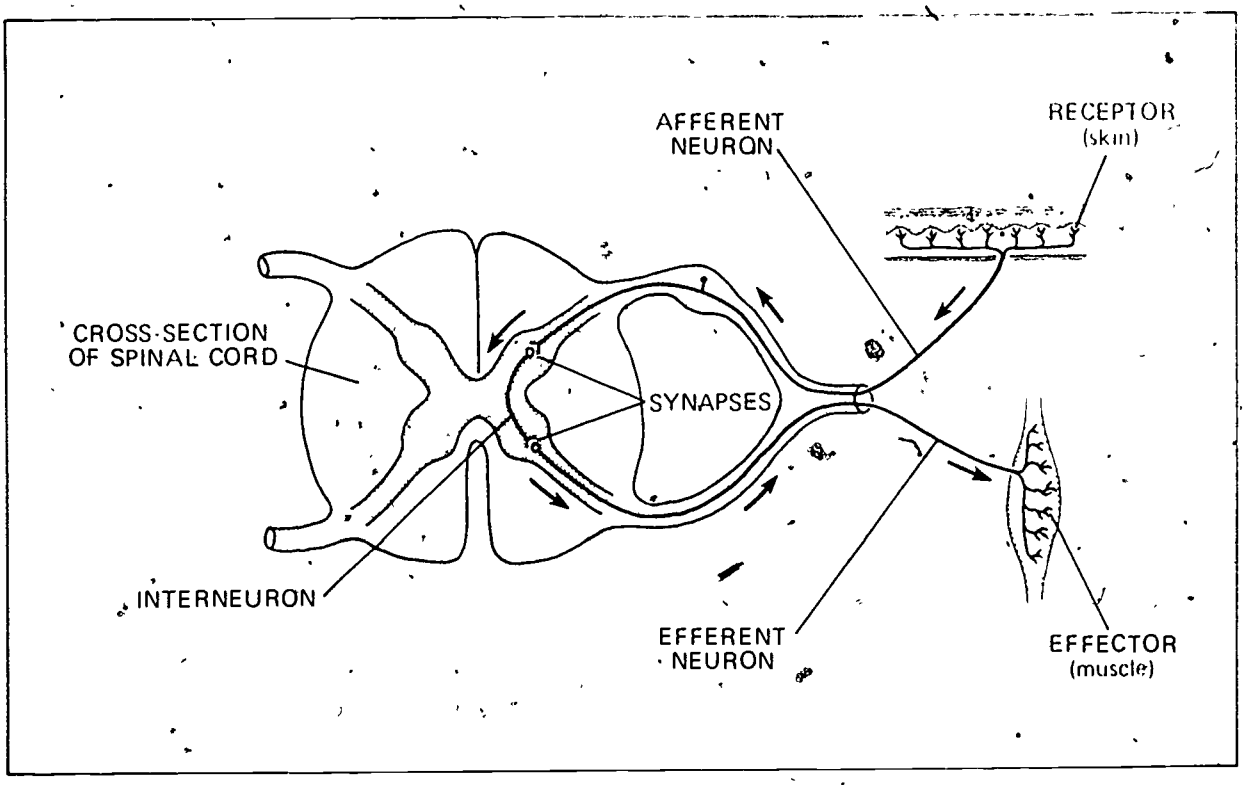


Figure 2. A Reflex Arc

An example of a simple reflex arc is what happens when you touch something that is very hot. Receptors in your fingers detect the dangerously high temperature. They generate an impulse in an afferent neuron which conducts the impulse to the spinal cord. The impulse synapses with an interneuron in the spinal cord and then directly with an efferent neuron. (The impulse does not have to go to the brain for a decision on what action to take.) The efferent neuron carries impulses to the effectors, the muscles of the arm, and causes them to contract. This pulls the fingers away from the hot object.

The action that results from a reflex arc is called a reflex action, or simply a reflex. All reflex actions have the following characteristics in common:

- The action is involuntary; it cannot be started or stopped at will.
- The action is stereotyped; that is, stimulation of a receptor in the same way will always cause the same response.
- The action serves a purposeful (usually protective) function.

Of course, reflex arcs vary in complexity. The receptor area may be dendrites of the afferent neuron itself. Or the reflex arc may have several sets of synapses in it: in the peripheral area, or in the central nervous system where several interneurons may intervene between the afferent and efferent neurons. Simple reflex arcs may synapse in the spinal cord; more complex reflex arcs may transmit impulses all the way to the brain.

OPTIONAL ACTIVITY

- Think of several reflex actions and describe how they protect the body.

THE CENTRAL NERVOUS SYSTEM

Objectives

Upon completion of this module, you should be able to:

1. Identify and describe the major parts of the brain (brain stem, cerebellum, cerebrum, and ventricles).
2. Identify and describe the regions, structures, and functions of the spinal cord.
3. Name the three meninges and describe their functions.

The central nervous system is located entirely within the skull and vertebral column and consists of just two organs: the brain and the spinal cord. The spinal cord is the first area where nerve impulses from the periphery of the body are received. Here they are routed through reflex responses or to the brain for further processing.

The brain is the major controlling organ of the body. It is the center of all thought, emotions, and intelligence. It is the organ that receives sensory impulses from the body and initiates motor impulses to the body. The average adult brain weighs about three pounds. It is divided into three major areas: the brain stem, the cerebellum, and the cerebrum. (See Figure 3).

The brain stem is located in the lower center of the head, where it connects directly to the spinal cord. The brain stem itself is divided into four major parts: the medulla oblongata, the pons, the midbrain, and the interbrain (or diencephalon).

The medulla oblongata is located in the lowest part of the brain stem, where it is a direct continuation of the spinal cord. The medulla is about one inch long and contains many nerve cell fibers (white matter) and cell bodies (gray matter). The main purpose of the medulla is to regulate several vital and nonvital body functions. The areas within the medulla that perform these functions are known as centers. The vital centers in the medulla are necessary for survival; these centers include the cardiac centers which control heart rate, the respiratory centers which regulate rate and depth of breathing, and the vasomotor centers which control blood pressure. Also located in the medulla are several nonvital centers, which control such things as swallowing, vomiting, coughing, and sneezing.

The pons is located between the midbrain and the medulla. It consists mostly of nerve fibers (white matter) passing from the medulla to the cerebrum. The pneumotaxic center, another respiratory center, lies within the pons. This center inhibits lengthy inspiration and contributes to expiration during the breathing cycle. No matter how long and hard you try to hold your breath, this involuntary center will eventually override your conscious control and force you to breathe again.

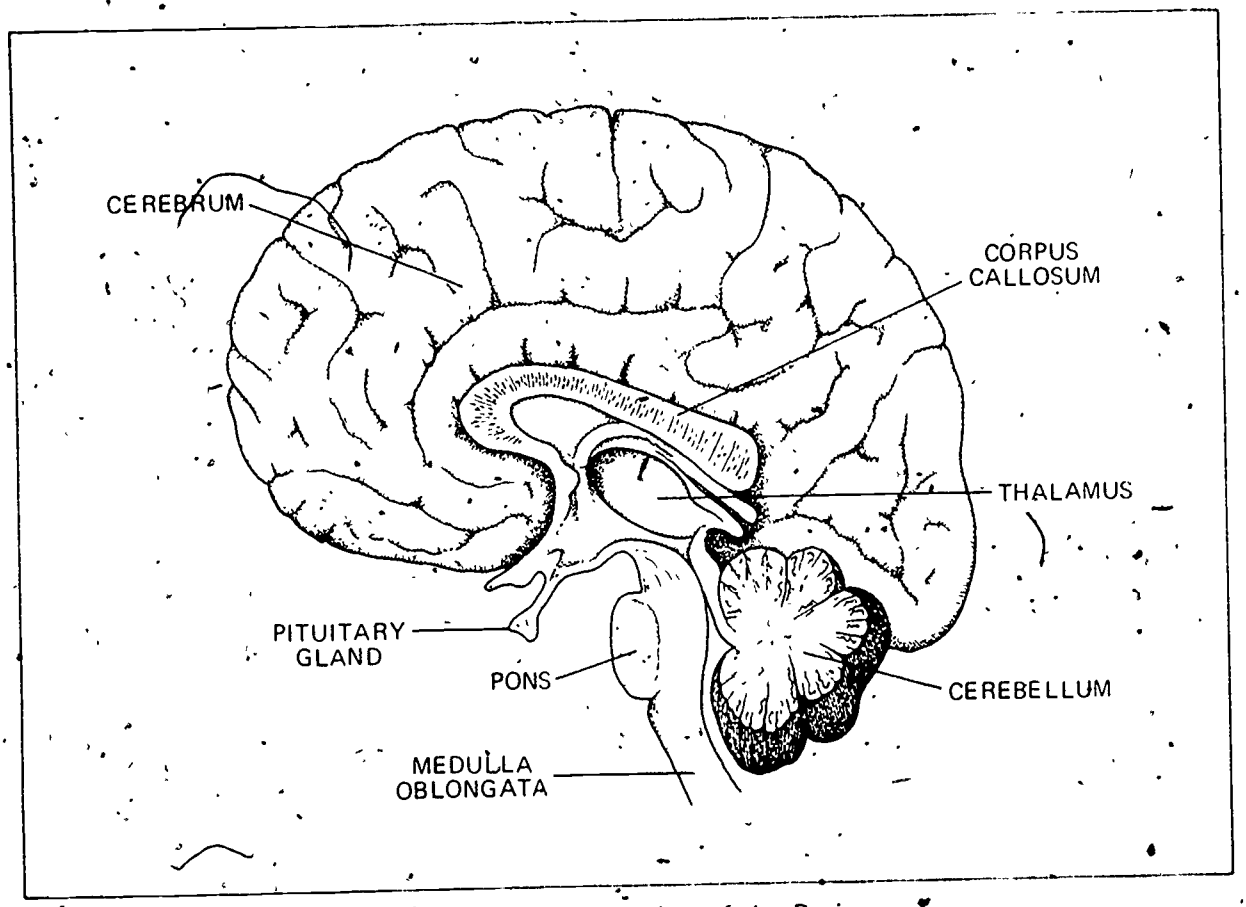


Figure 3. Cross-section of the Brain

The midbrain connects the pons and cerebellum with the cerebrum. It too is made up largely of bundles of fibers carrying impulses from the cerebrum to lower areas of the brain stem and to the spinal cord. Most of the functions of the midbrain concern reflex reactions, especially auditory and visual ones. These include such actions as turning the head in order to hear something better or moving the head (turning, ducking) in order to avoid an oncoming object. The midbrain also appears to be concerned with maintaining balance and posture.

The top portion of the brain stem is formed by the interbrain, or diencephalon. It consists of the thalamus, and located directly below, the smaller hypothalamus. About four-fifths of the interbrain is the thalamus, an organ located near the center of the brain. The thalamus is a highly diverse organ and is concerned with hundreds of body functions. It acts as a sort of relay station; where impulses from different parts of the body are grouped according to similarities (e.g., pain) and relayed to other areas of the brain. Impulses from all of the senses (except smell) are integrated by the thalamus and channeled for further processing. The thalamus is also involved in the state of alertness or wakefulness of the body and seems to be able to differentiate between and rank the pleasantness or unpleasantness of a stimulus.

The lower portion of the interbrain is formed by the hypothalamus. The hypothalamus is connected to the thalamus, the cerebral cortex, and through a stalk of nerve fibers and blood vessels, to the pituitary gland. The primary function of the hypothalamus is to maintain homeostasis (the proper state and balance of body functions). Toward this end, the hypothalamus is involved in temperature and water-balance regulation, the control of food intake (hunger), the regulation of gastric secretions, emotional expression, and the control of pituitary functions. (See "The Pituitary Gland" module.)

The second major (and second largest) portion of the brain is the cerebellum or hindbrain. It is connected to, and lies immediately behind, the medulla and pons. The cerebellum is made up of two cerebellar hemispheres connected in the middle by the vermis. This gives the cerebellum, when viewed from behind, a shape similar to a fully-opened clamshell. All functions of the cerebellum are beyond conscious control: it operates completely subconsciously. Cerebellar functions mainly involve the coordination and integration of muscle movements. It is important to note that the cerebellum does not initiate movements but rather is responsible for their smooth and balanced executions. It also coordinates reflexes that maintain balance and equilibrium.

The largest and most significant part of the brain is the cerebrum. It is divided into two mirror-image halves called hemispheres, each primarily concerned with movements and sensations of one side of the body. The right hemisphere controls the left side of the body and vice versa. The hemispheres make up about 70% of the brain. Structurally, they are each composed of an outer layer of gray matter called the cortex, and an inner layer of white matter called the medullary body. The two hemispheres are connected by a bundle of fibers called the corpus callosum. Each hemisphere is divided functionally into four lobes: the occipital, temporal, frontal, and parietal lobes. The occipital lobe receives and analyzes visual information, the temporal lobe is concerned primarily with learning and memory of things seen and heard, the frontal lobe regulates voluntary movement, and the parietal lobe is associated with the senses of touch and balance. There are obviously thousands of other functions involving intellect, personality, and sensory-motor integrations that are performed within the cerebral hemispheres; however, an extensive discussion of these is beyond the scope of this module.

Other important features of the brain are the ventricles. The ventricles are a series of cavities located inside the brain that are filled with cerebrospinal fluid. There are four true ventricles: the right and left lateral ventricles, located within the cerebral hemispheres; the third ventricle, located in the interbrain; and the fourth ventricle, located in the pons and medulla. The lateral ventricles and the fourth ventricle are each connected to the third ventricle by a small channel. The fourth ventricle communicates by a channel with the spinal cord below. Vascular structures within the ventricles secrete the cerebrospinal fluid, which is derived from the blood. This fluid surrounds the brain and spinal cord serves mainly as a lubricant and a mechanical barrier to dissipate the shock of any blows to the head. Because cerebrospinal fluid completely surrounds the brain, the brain literally floats within the skull. In this manner the fluid also helps bear the weight of the brain.

The second organ of the central nervous system, the spinal cord, is located within a hollow canal that runs through the center of the vertebral column. In an adult, the cord is about 18 inches long; it runs from the base of the brain stem to the second lumbar vertebra. The cord is divided into three regions: an upper cervical, a middle thoracic, and a lower lumbosacral region. A cross-section of the cord shows an H-shaped core of gray matter surrounded by fibers of white matter which run up and down the cord.

The main functions of the spinal cord include relaying information to and from the brain, and controlling spinal reflexes. (Reflex arcs are discussed in another module.)

Surrounding both the brain and spinal cord are three protective membranes called the meninges. The outer membrane, the dura mater, is a tough fibrous layer; the middle arachnoid is a thin, web-like tissue that encloses a space containing the cerebrospinal fluid; and the inner layer, the pia mater, is a soft lining which contains many blood vessels. The pia mater is also involved in the secretion of cerebrospinal fluid.

The central nervous system, along with its supporting structures is responsible for initiating, evaluating, coordinating, and/or integrating nearly every process occurring in the body.

OPTIONAL ACTIVITIES

- Investigate spinal cord injuries and the different results of injuries at different levels of the cord.
- Find out why many strokes affect the use of only one side of the body.

THE PERIPHERAL NERVOUS SYSTEM

Objectives

Upon completion of this module, you should be able to:

1. Describe the structure and functions of the sensory-somatic nervous system.
2. Describe the structure and functions of the autonomic nervous system.

The peripheral nervous system is the part of the nervous system that lies outside the skull and vertebral column. It is usually divided into two systems: the sensory-somatic nervous system and the autonomic nervous system.

The sensory-somatic system is not actually one system, but rather a collection of different systems. It includes the nerves that supply the skin and skeletal muscles, more specifically, the spinal and cranial nerves.

There are 31 pairs of spinal nerves, each arising from a certain area of the spinal cord. They are named according to where they originate: there are 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal nerve pair. Spinal nerves disperse to skin and muscle regions throughout the body. There is an overlap of functions with neighboring nerves so if damage to a nerve should occur there will not be a complete loss of function in that region. The spinal nerves leave the spinal column through small holes between vertebrae which, in the upper cord, are near the nerves' points of origin. However, in the lower segment (because the cord is shorter than the spinal column), some spinal nerves must travel downward to reach their points of exit. Large bundles of these nerves form a sort of continuance to the spinal cord called the cauda equina (literally, horse's tail).

In several areas of the body groups of spinal nerves combine to form a complex nerve network called a plexus. From these, nerves are distributed to nearby regions of skin and muscle. The major nerve plexuses are the cervical plexus of the neck, the brachial plexus of the upper arm, the lumbar plexus of the lower back, and the sacral plexus of the pelvis.

The cranial nerves are 12 pairs of major nerves which arise from the brain and brain stem. These nerves supply sensory and motor fibers which innervate muscles, glands, mucous membranes, skin, and the special senses of the head, neck, and upper chest regions. (One nerve, the vagus nerve, extends as far as the abdomen.) Cranial nerves are identified by both a name and a number (Roman numerals I through XII). The names and numbers of the 12 cranial nerves are as follows: I, Olfactory; II, Optic; III, Oculomotor; IV, Trochlear; V, Trigeminal; VI, Abducent; VII, Facial; VIII, Vestibulocochlear (or Auditory); IX, Glossopharyngeal; X, Vagus; XI, Accessory; XII, Hypoglossal.

Table 1 charts the composition and function of each of the cranial nerves.

TABLE 1

Nerve	Composition M = motor S = sensory	Function
I. Olfactory	S	Smell
II. Optic	S	Sight
III. Oculomotor	M	Eye movements
	S	Focusing, pupil changes, muscle sense
IV. Trochlear	M	Eye movement
	S	Muscle sense
V. Trigeminal	M	Chewing
	S	Sensation from head
VI. Abducent	M	Eye movement
	S	Muscle sense

TABLE 1
(Continued)

Nerve		Composition M = motor S = sensory	Function
VII.	Facial	M	Facial expression
		S	Taste
VIII.	Vestibulocochlear (statoacoustic, acoustic, auditory)	S	Posture, hearing, balance
IX.	Glossopharyngeal	M	Swallowing
		S	Taste, general sensation
X.	Vagus	M	Visceral muscle movement
		S	Visceral sensation
XI.	Accessory	M	Swallowing, head movement
XII.	Hypoglossal	M	Speech, swallowing

The autonomic nervous system serves the autonomic effectors: the heart muscle, smooth muscle, and glands of the body. It consists of two further divisions, the sympathetic division and the parasympathetic division. Most of the autonomic nervous functions are completely subconscious, operating at the reflex level.

The parasympathetic division or system consists of nerve fibers that arise from four of the cranial nerves and three spinal nerves from the sacral region. Parasympathetic fibers supply all of the autonomic effector organs except the adrenal medulla, sweat glands, smooth muscles of the spleen, and surface blood vessels. This system is concerned with protecting and maintaining body resources and generally promoting normal body functions.

The sympathetic system consists of fibers that originate from spinal nerves of the thoracic and lumbar regions. This system supplies all of the autonomic effectors. Activation of the sympathetic system increases the use of body resources and prepares the body to react to dangerous or stressful situations (sometimes called the "fight-or-flight" reaction).

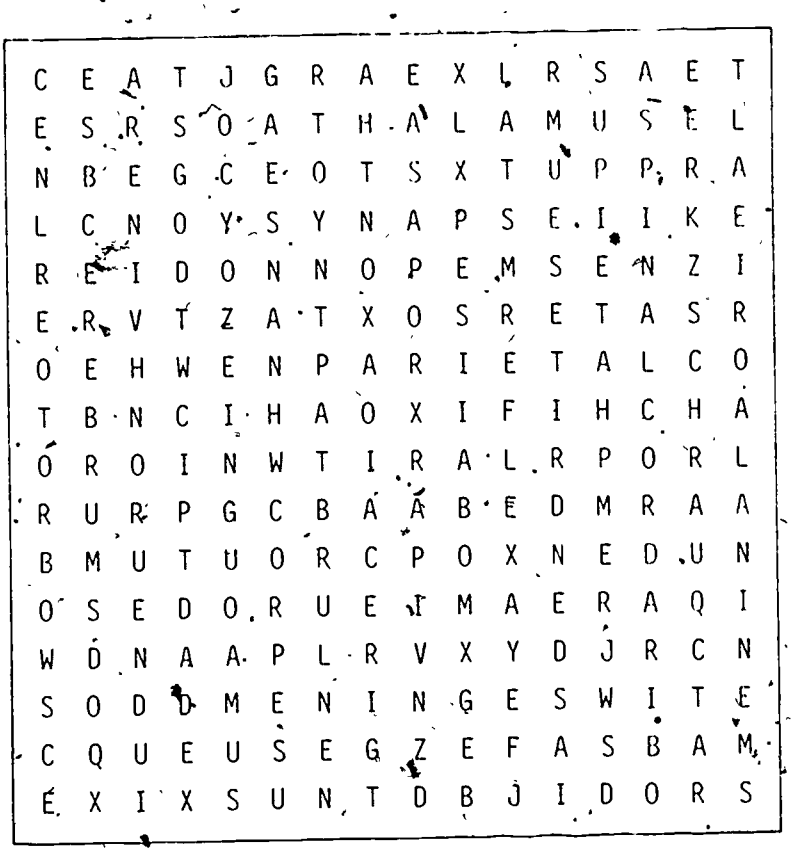
Table 2 charts some of the effects of the autonomic nervous system.

TABLE 2

Autonomic Nervous System Effects

Organ	Parasympathetic Effects	Sympathetic Effects
Eyes	Decreases pupil size Contraction (near-vision) Tear secretion	Increases pupil size Relaxation (distant vision) Greater tear secretion
Salivary glands	Secretion of large amounts of saliva	Secretion of small amounts of saliva
Respiratory system	Contraction of smooth muscle	Relaxation of smooth muscle
Heart	Decreases stroke volume Decreases heart rate Decreases blood pressure	Increases stroke volume Increases heart rate Increases blood pressure
Blood vessels	Constriction	Dilation
Liver	Promotes glycogenesis and bile secretion	Promotes glycogenolysis; decreases bile secretion
Pancreas	Stimulates endocrine and exocrine secretions	Inhibits endocrine and exocrine secretions
Adrenal medulla	No innervation	Secretion of epinephrine (adrenalin)
Urinary bladder	Inhibits sphincter	Stimulates sphincter
Sweat glands	No innervation	Stimulates secretion

OPTIONAL ACTIVITY



C E A T J G R A E X L R S A E T
E S R S O A T H A L A M U S E L
N B E G C E O T S X T U P P R A
L C N O Y S Y N A P S E I I K E
R E I D O N N O P E M S E N Z I
E R V T Z A T X O S R E T A S R
O E H W E N P A R I E T A L C O
T B N C I H A O X I F I H C H A
O R O I N W T I R A L R P O R L
R U R P G C B A A B E D M R A A
B M U T U O R C P O X N E D U N
O S E D O R U E I M A E R A Q I
W D N A A P L R V X Y D J R C N
S O D D M E N I N G E S W I T E
C Q U E U S E G Z E F A S B A M
E X I X S U N T D B J I D O R S

Find the following terms in this maze by circling the words. They may appear frontwards or backwards, vertically, horizontally, or diagonally.

axon	meninges	spinal cord
cerebrum	neuron	sympathetic
conductors	parietal	synapse
dendrite	reflex	thalamus

GLOSSARY

afferent neuron: neuron that conducts impulses toward the brain or spinal cord.

all-or-none law: property of neurons whereby a nerve fiber responds maximally to a stimulus or not at all.

arachnoid membrane: middle of three membranes surrounding the brain and spinal cord.

association neuron: neuron lying between and transmitting impulses between sensory and motor neurons (interneuron).

autonomic nervous system: division of the peripheral nervous system, controls involuntary body functions.

axon: long, stem-like part of nerve cell body, conducts nerve impulses away from cell body.

brain: the major controlling organ of the body, a part of the central nervous system.

brain stem: all of the brain except the cerebellum and cerebrum, located in the lower center of the head.

cauda equina: spinal nerves forming the terminal portion of the spinal cord.

cell body: central part of cell, contains the cell nucleus and cytoplasm.

central nervous system: the brain and spinal cord.

cerebellar hemisphere: one of two hemispheres which, in addition to the vermis, constitute the cerebellum.

cerebellum: portion of the brain responsible for subconscious execution and coordination of muscle movement.

cerebral cortex: outer layer of gray matter of the cerebral hemispheres.

cerebrospinal fluid: fluid surrounding the brain and spinal cord, protects them from shock.

cerebrum:	largest part of the brain, divided into two hemispheres, each concerned with the movements and sensations of one side of the body.
cervical region:	upper region of the spinal cord.
conductivity:	property of neurons which enables nerve impulses to be transmitted by exciting successive segments of a nerve fiber.
conductors:	interneurons, relay impulses within the central nervous system.
corpus callosum:	bundle of fibers which connect the two cerebral hemispheres.
cranial nerves:	twelve pairs of nerves originating in the brain.
dendrites:	branching portions of a neuron, receive and conduct impulses to the cell body.
diencephalon: (interbrain)	a central portion of the brain, includes thalamus and hypothalamus.
dura mater:	outer membrane surrounding the brain and spinal cord.
effectors:	muscles and glands capable of responding to stimuli from the central nervous system.
efferent neuron:	neuron which conducts impulses away from the brain or spinal cord.
excitability:	property of neurons in which there is a reaction to a stimulus by generation of an impulse.
frontal lobe:	one of four functional divisions of the cerebral hemispheres, regulates voluntary movement.
gray matter:	nervous tissue containing cell bodies of neurons.
hemisphere:	either half of the cerebrum or cerebellum.
hypothalamus:	lower portion of the diencephalon, maintains body homeostasis.
impulse:	reaction which transmits a communication along nerve fibers.
interbrain:	a portion of the brain, includes thalamus and hypothalamus (diencephalon).

interneuron:	neuron lying between and transmitting impulses between other neurons (association neuron).
lumbosacral region:	lower region of the spinal cord.
medulla oblongata:	lower portion of the brain stem, continuation of the spinal cord.
medullary body:	inner layer of the cerebral hemispheres, composed of white matter.
meninges:	three membranes surrounding the central nervous system.
midbrain:	part of the brain stem, concerned with reflex reactions, maintaining balance.
motor neuron:	neuron which transmits impulses from the spinal cord and brain to body parts.
myelin:	fatty substance which forms an insulating sheath around an axon.
neuron:	nerve cell, basic unit of the nervous system, transmits communications throughout the body.
occipital lobe:	one of four lobes of the cerebral hemisphere, receives and analyzes visual information.
parasympathetic division (system):	division of the autonomic nervous system, maintains body resources and normal body functions.
parietal lobe:	one of four lobes of the cerebral hemisphere, concerned with senses of touch and balance.
peripheral nervous system:	the part of the nervous system lying outside the skull and vertebral column, subdivides into the sensory-somatic and autonomic nervous systems.
pia mater:	innermost membrane of the three meninges, surrounds the brain and spinal cord.
plexus:	nerve network formed by groups of spinal nerves.
pons:	portion of the brain stem, consists mainly of white matter, contains the pneumotaxic center.
receptors:	sensory neurons which transmit impulses in response to specific stimuli from the environment.

reflex action:	involuntary act resulting from a reflex arc.
reflex arc:	involuntary reaction between a receptor and an effector.
sensory neuron:	afferent neuron, conveys sensory impulses.
sensory-somatic nervous system:	subdivision of the peripheral nervous system, includes the spinal and cranial nerves.
special senses:	perceptions through various organs of conditions outside and inside the body, include sight, hearing, taste, touch, smell.
spinal cord:	column of nervous tissue, center of reflex actions, conducts transmissions to and from the brain; a subdivision of the central nervous system.
spinal nerves:	31 pairs of nerves arising from the spinal cord, supply the skin and skeletal muscles.
sympathetic division (system):	division of the autonomic nervous system, prepares the body to react to stressful situations.
synapse:	gap between the axon end of one neuron and the dendrites of another neuron.
temporal lobe:	one of four divisions of the cerebral hemispheres, concerned with learning and memory.
thalamus:	upper portion of the interbrain, concerned with many diverse body functions.
thoracic region:	middle region of the spinal cord.
tracts:	nerve fibers, groups of axons within the spinal cord or brain.
ventricles:	small cavities within the brain filled with cerebrospinal fluid.
white matter:	white substance of the spinal cord and brain, consists of nerve fibers.

The Nervous System
POST-TEST

1. A nerve cell is known as a:

_____

2. Name the two major divisions of the nervous system.

_____

_____

3. What division of the nervous system operates beyond the level of conscious control?

_____

4. The nervous system relays coded communications from one area of the body to another through the transmission of:

A. chemicals.
B. impulses.
C. senses.
D. stimuli.

5. Name the two divisions of the autonomic nervous system.

_____

_____

6. Which of the following is an important function of the nervous system?

A. controlling the external environment
B. regulating the growth of body tissues
C. coordinating the movement of muscles
D. providing nutrients for body cells

7. The junction between two nerve cells is called a:

A. threshold.
B. stimulus.
C. reflex.
D. synapse.

8. The long, thin part of a nerve cell that conducts impulses away from the cell body is called the:

_____.

9. Which nerve cells only carry messages toward the central nervous system?

A. motor neurons
B. interneurons
C. sensory neurons
D. association neurons

10. All neurons will react to a proper stimulus by generating an impulse. What property of neurons does this illustrate?

_____

11. An impulse generated in a neuron will be transmitted through the entire cell. What property of neurons does this illustrate?

_____

12. Impulse transmission within a neuron occurs electrically, but across a synapse it occurs:

_____

13. Neurons that monitor the environment are called:

A. effectors.
B. coordinators.
C. receptors.
D. conductors.

14. Name the three major divisions of the brain.

_____

_____

_____

15. Which part of the brain contains cardiac, respiratory, and vasomotor centers?

A. interbrain
B. midbrain
C. pons
D. medulla

16. The pneumotaxic center is located in what division of the brain stem?

_____

17. Name the two organs that form the interbrain.

_____

_____

18. What division of the brain operates solely at the subconscious level?

_____

19. The cerebral hemispheres are connected by a bundle of fibers called the:

_____

20. Name the four lobes of the cerebral hemispheres.

_____

_____

_____

_____

21. Which structures of the brain are filled with cerebrospinal fluid?

A. nerves
B. ventricles
C. hemispheres
D. lobes

22. Which of the following is a major function of the spinal cord?

A. controlling reflexes
B. producing cerebrospinal fluid
C. initiating breathing
D. regulating internal temperature

23. List the three meninges.

_____

_____

_____

24. The major controlling organ of the nervous system is the:

A. spinal cord.
B. heart.
C. brain.
D. stomach.

25. Name the two organs of the central nervous system.

_____

_____

26. The three membranes that surround the organs of the central nervous system are collectively called the:

_____

27. The portion of the brain that is responsible for smooth and balanced executions of movements is the:

A. cerebellum.
B. pons.
C. hypothalamus.
D. medulla.

28. There are how many pairs of spinal nerves?

A. 8
B. 12
C. 20
D. 31

29. Name the two major systems (divisions) of the peripheral nervous system.

_____

_____

30. Write in the number of pairs of spinal nerves that originate in each spinal region below.

cervical ____
thoracic ____
lumbar ____
sacral ____
coccygeal ____

31. The 12 pairs of nerves arising from the brain that supply fibers to the head, neck, and chest regions are the:

_____

32. In several body regions, groups of spinal nerves form complex networks called:

A. effectors.
B. plexuses.
C. receptors.
D. reflexes.

33. Which cranial nerve is responsible for the sense of smell?

A. olfactory
B. optic
C. oculomotor
D. trochlear

34. List the three autonomic nervous system effectors.

_____

_____

_____

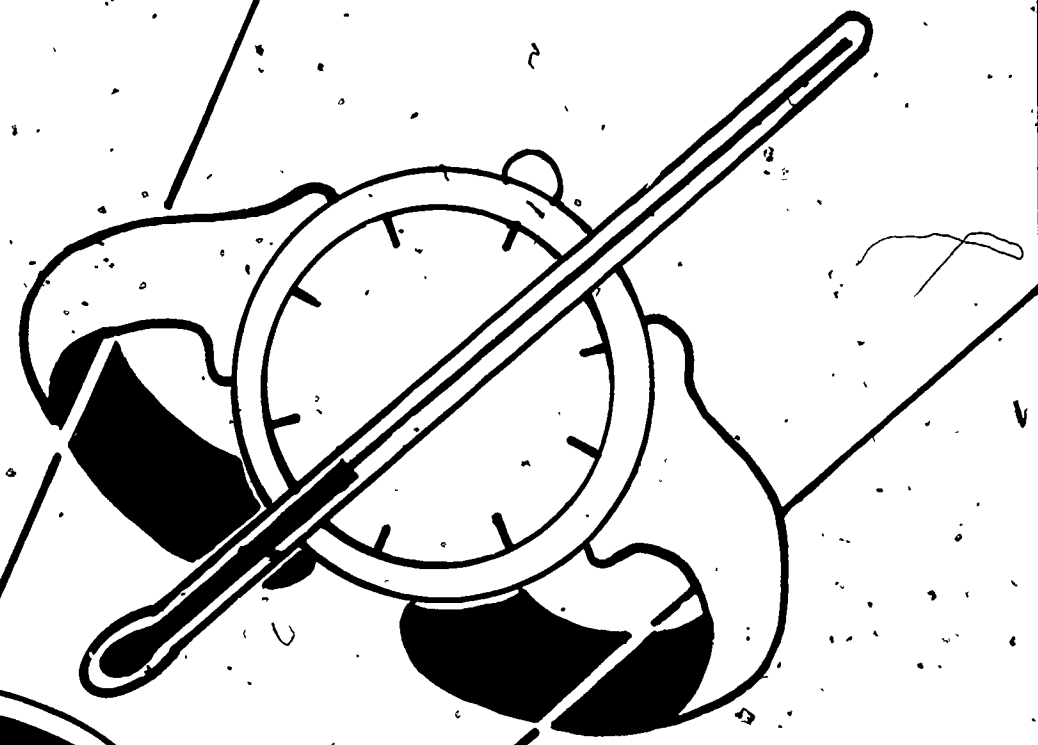
35. The division of the autonomic system that is concerned with maintaining body resources and normal body functions is the:

_____

36. Name the division of the autonomic nervous system that prepares the body for dangerous or stressful situations.

_____

HEALTH OCCUPATIONS EDUCATION MODULE



INSTRUCTOR'S GUIDE: THE NERVOUS SYSTEM

Instructional Materials in Anatomy and Physiology
for Pennsylvania Health Occupations Programs

INSTRUCTOR'S GUIDE:

THE NERVOUS SYSTEM

Prepared for:

Research Coordinating Unit for Vocational Education
Pennsylvania Department of Education
Box 911
Harrisburg, Pennsylvania 17126

Prepared by:

National Evaluation Systems, Inc.
30 Gatehouse Road
Amherst, Massachusetts 01002

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INTRODUCTION

These instructional modular units have been developed for the Pennsylvania Department of Education for use in vocational education programs. They were designed on the assumption that a basic understanding of human anatomy and physiology is essential to any person preparing to enter a health care occupation such as practical nursing, nursing assistant, medical assistant, emergency medical technician, or dental assistant. Each of these modular units will cover the most important aspects of one of the major systems of the human body. In the first four units the following systems are covered: circulatory system, respiratory system, musculoskeletal system, and digestive system. In the second four units, the endocrine, reproductive, nervous, and genitourinary systems are covered.

This Instructor's Guide is designed to provide suggestions on how to use a modular unit most effectively in your instruction. These recommendations, however, do not represent the only way to use these units: you may be able to devise more beneficial uses for the materials.

THE MODULAR UNITS

Each modular unit is made up of several components: a pretest, three to six instructional modules with optional activities for the students, a glossary of terms used in the unit, and a post-test. Each of these components has a specific purpose and is organized in a specific way, as explained in the following sections.

Pretest

After reading the preface, which is simply an introduction to these instructional units, students working through a modular unit should first take the pretest. Their answers should be written on a separate piece of paper labeled "Pretest" (they should not have access to these answers when taking the post-test). As its name

implies, this test is designed to be taken by the student before beginning work on the materials contained in the unit. Its purpose is twofold: (1) to stimulate interest in the modular unit by giving the student a preview of the topics covered, and (2) to provide information to the instructor on what students do and do not know, before and after working through the unit. Based on the student's performance on the pretest, the instructor may wish to emphasize those areas of the modular unit which may require special attention and extra effort on the part of the students. Instructors should score the pretests after the students have completed them, but should not share these scores with the students. After completing the unit, students will then take the post-test (which involves all of the questions on the pretest, and more). Instructors may then compare post-test scores to pretest scores in order to evaluate the amount that students have learned from the unit.

Instructional Modules

This modular unit is composed of four separate but closely related modules, including: Introduction to the Nervous System, Nerve Impulse Conduction, The Central Nervous System, and The Peripheral Nervous System. After taking the pretest, students should read through and study each of the instructional modules. For the students' benefit, each module begins with a statement of the objectives that a student should have mastered upon completion of that particular module. The level of achievement of these goals is measured by students' performance on the corresponding section of the final post-test. The language level and content of each module is aimed toward students seeking an introduction to the components, structures and functions, and the basic terminology required for an understanding of the nervous system. However, some material may be too technical or otherwise inappropriate for certain programs. Instructors are urged to use their judgment to determine if any areas are too difficult and should be omitted.

Optional Activities

Following many modules are optional activities intended to provide the student with an opportunity to pursue the content of the module at a more in-depth level. Many of these activities may require teacher participation, at least in obtaining and preparing additional materials for students to utilize.

In addition to the optional activities available, you may choose to provide further information to the students by teaching a brief unit on the common disorders of the nervous system. Discussion of these disorders has not been included in the

text because a basic knowledge of the proper structure and function of the human body in a healthy individual seems more appropriate for the purposes of an introductory program. If you do choose to discuss common disorders, the most effective approach may be one in which you use disorders to illustrate what can go wrong in the body, as a means of clarifying the students' understanding of how the body works when functioning properly.

You may also wish to provide students with the names of books or articles as suggested readings to further their understanding of a particular area.

Glossary

After the last of the modules in the unit is a glossary. This is not intended to be a comprehensive glossary to be used by students as a dictionary. Rather, it includes the basic terms used in the unit which are necessary to an understanding of the system covered. Those underlined words which appear in the modules and have been defined in the text are not always defined in the glossary. Some of these particular terms have been used in the module because they are essential but difficult terms needed to explain the content taught in the unit. Students should use the glossary to review the vocabulary essential to the unit before taking the post-test.

Post-Tests

The post-test is the final assessment of a student's understanding of the material presented in each module. It consists of multiple-choice and open-ended questions designed to measure a student's mastery of the objectives stated at the beginning of each module. Each of the questions has been written to measure an aspect of the skills and/or knowledge that a student may be expected to acquire as a result of working through a particular unit. The post-test includes the questions used in the pretest, which can be used for before-and-after comparisons; and it includes additional difficult questions which measure knowledge of subjects treated specifically in the modules.

SCORING THE POST-TESTS

As previously mentioned, the purpose of the post-tests is to measure whether or not a student has mastered the objectives stated at the beginning of each module. Due to the variety of ways in which teachers may choose to utilize these modules, and discrepancies among students' previous exposure to the subject matter, it is not practical to set a standard cut-off score on the post-test that would indicate mastery of the objectives. Rather, teachers are asked to use their professional judgment in individual cases to determine if a student's performance on the post-test indicates that he or she has mastered the objectives stated for the modules. In making this determination, you should consider at least all of the following factors:

(1) How long is the post-test?

(2) How much information is included in each module and how complex is the information, relative to other modules?

(3) Has the student been exposed to the kind of curricular material before? That is, has the student been taught the basics of this system of the body before?

(4) Should the entire class be required to achieve a certain score in order to pass, or should each student be considered individually? (This depends on how and with whom you use this module as instructional material.)

(5) Should the student be graded pass/fail on mastery of objectives in each module, or on the unit as a whole?

To facilitate the scoring of the post-test, each student will record his or her answers on one separate sheet of paper. You should first mark each answer correct or incorrect. Then give the student a "pass" or "fail" on each module by counting the questions answered correctly, or score the unit as a whole by adding up all of the correct answers.

Because of the subject matter, responses to open-ended questions may vary slightly from those provided, but these responses may also be acceptable. Again, in these cases instructors are asked to use their professional judgment to determine if a response is correct.

In order to compare the students' scores on the pretest and post-test, review the scores each student achieved on the pretest, then total the score students achieve on these same questions appearing in the post-test. (Please note: these questions have been placed in different sequence and renumbered; both their old and new numbers are listed in the answer key.) You may wish to compare the students' scores on the entire set of items which appears in both tests, or on the items for each module, or on each item individually. Whichever approach seems most useful can be accomplished by using the information given.

On the following pages is a list of answers to the pretest and post-test questions, which is provided to facilitate the grading of your students' papers.

ANSWER KEYS

Pretest

1. sympathetic system, parasympathetic system
2. neuron
3. B
4. D
5. axon
6. C
7. brain, spinal cord
8. meninges
9. A
10. D
11. brain stem, cerebellum, cerebrum
12. D
13. cranial nerves
14. sympathetic system
15. B
16. heart muscle, smooth muscle, glands
17. A
18. B

Post-test

NOTE: Starred question numbers indicate those questions which also appeared on the pretest. The pretest number of each repeated question is given in parentheses. Post-test questions 1-6 refer to materials presented in module 1, Introduction to the Nervous System; questions 7-13 refer to module 2, Nervous Impulse Conduction; questions 14-27 refer to module 3, The Central Nervous System; and questions 28-36 refer to module 4, The Peripheral Nervous System.

*1. (2) neuron
2. central nervous system, peripheral nervous system
3. autonomic system
*4. (3) B
*5. (1) sympathetic system, parasympathetic system
6. C
*7. (4) D
*8. (5) axon
9. C
10. excitability
11. conductivity
12. chemically

13.		C	*21.	(18)	B	29.	sensory-somatic, autonomic
*14.	(11)	brain stem, cerebellum, cerebrum	*22.	(17)	A	30.	8, 12, ~~5, 5, 1~~
*15.	(10)	D	23.		dura mater, arachnoid, pia mater	*31.	(13) cranial nerves
16.		pons	*24.	(6)	C	*32.	(15) B
17.		thalamus, hypothalamus	*25.	(7)	brain, spinal cord	33.	A
18.		cerebellum	*26.	(8)	meninges	*34.	(16) heart muscle, smooth muscle, glands
19.		corpus callosum	*27.	(9)	A	35.	parasympathetic system
20.		frontal, temporal, parietal, occipital	*28.	(12)	D	*36.	(14) sympathetic system